

DEPARTMENT OF ENERGY
FY 2002 CONGRESSIONAL BUDGET REQUEST

FOSSIL ENERGY RESEARCH AND DEVELOPMENT

Program Mission

The U.S. relies on fossil fuels for about 85% of the energy it consumes. Many forecast that high U.S. reliance on these fuels will continue for decades. For example, the Energy Information Administration's 2001 Annual Energy Outlook projects that fossil fuel reliance could approach 90% by 2020. Accordingly, a key goal of the Department's fossil energy activities is to ensure that economic benefits from moderately-priced fossil fuels, and a strong domestic industry that creates export-related jobs, are compatible with the public's expectation for exceptional environmental quality and reduced energy security risks.

In support of this goal, the mission of the Fossil Energy (FE) Research and Development (R&D) program is to enhance U.S. economic and energy security by: (1) managing and performing energy-related research that promotes the reliable, efficient and environmentally sound production and use of fossil fuels; (2) partnering with industry and others to advance clean and efficient fossil energy technologies toward commercialization in the U.S. and international markets, and: (3) supporting the development of information and policy options that benefit the public by ensuring access to adequate supplies of affordable and clean energy.

To ensure that Federally funded and developed technologies and related analysis are relevant to market and public needs, and are transferred into commercial applications, FE participates in joint partnerships with industry utilizing a variety of mechanisms such as cost-shared contracts, targeted outreach activities, and cooperative research and development agreements with the Department's National Energy Technology Laboratory (NETL) and other National Laboratories.

Program Areas

The FY 2002 request for R&D is \$449.0 million. Comparable activities (i.e., R&D plus demonstrations) were funded at \$450.5 million in FY 2001, not including a transfer of \$95 million that does not come available for obligation until September 30, 2001. Including this funding, Fossil R&D was funded at \$545.5 million. In FY 2002 there are significant changes in emphasis within the R&D portfolio. In

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particular, additional funding is requested for activities under a new Clean Coal Power Initiative to demonstrate technology for advanced clean coal powerplants. Turbine R&D is eliminated and R&D funding for natural gas, petroleum, and clean fuels (from coal, oil and natural gas) is significantly reduced.

Clean Coal Power Initiative

The Bush Administration is proposing a new vision in coal research. This Presidential Initiative is a new effort within the Department of Energy's Fossil Energy program that combines investments in research and development with federal matching funds for research and development and first-of-a-kind installations of advanced technologies on coal-fired power plants. As part of this initiative, the administration is requesting \$150 million in FY 2002 for funding advanced research and development and a limited number of joint government-industry-funded demonstrations of new technologies that can enhance the reliability and environmental performance of coal-fired power generators. The nation's power generators, equipment manufacturers, coal producers and others will help identify the most critical barriers to coal's use in the power sector. Industry also will be required to share in the costs of the initiative, with the private participants' share rising to 50 percent or more by the time new technologies are ready for testing at market-entry scales.

Fuels and Power Systems

In FY 2002 Coal and Power Systems has been re-named Fuels and Power Systems. While this area continues to encompass the Department's coal-related R&D, the name change highlights the multi-resource nature (e.g., oil, gas, coal) of fossil energy power and fuel systems. The FY 2002 request for Fuels and Power Systems is \$159.8 million. The FY 2001 appropriation for comparable R&D activities is \$229.2 million. In FY 2001 Fuels and Power Systems also included an additional \$94.8 million for the Power Plant Improvement Initiative.

Fuels and Power Systems addresses demands of the post-2000 domestic market, including the need for reliable, moderate-cost electricity generation that can reduce emissions consistent with evolving environmental requirements while meeting growing electricity demand. These activities will also help U.S. industry develop options for a large and growing export market, while contributing to national energy security. Based on these priorities, the coal program is focused on four goals: (1) develop progressively higher efficiency and cleaner

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power generation systems with 10-20% lower busbar electricity costs, which will ultimately evolve into a "Vision 21" fleet of new power and energy plants with near zero levels of pollutants as well as CO₂; (2) develop super-clean emission control systems for SO₂, NO_x, air toxics, and particulate matter that can be applied to existing plants; (3) evaluate economically viable approaches to carbon sequestration to address climate change concerns, and ; (4) develop economically competitive technologies for the production of alternative transportation fuels and chemicals.

The Vision 21 concept integrates program goals to develop the full potential of our abundant fossil fuel resources while addressing climate change concerns. Vision 21 was endorsed in the November 1997 report on Energy R&D by the President's Committee of Advisors on Science and Technology (PCAST), and supported by the National Research Council and other stakeholder groups. Vision 21 plants would comprise a portfolio of fuel-flexible systems and modules capable of producing a varied slate of high-value fossil fuels, (or in combination with opportunity fuels or feed-stocks) commodities and/or electricity tailored to market demands in the 2010-2015 time frame. Distinguishing features of the Vision 21 fleet are (1) capability to produce cheaper electricity at efficiencies over 60 percent when fueled by coal, and 75 percent when fueled with natural gas; (2) near zero pollutants to meet more stringent emissions standards (less than one-tenth of current New Source Performance Standards) at a lower cost; (3) options for no net CO₂ emissions; (4) fuel flexible (coal, natural gas, plus opportunity fuels such as municipal and industrial wastes); and (5) a flexible set of integrated modules configured to meet a range of market applications and capable of producing an array of high-value commodities (such as chemicals, high-quality steam, liquid fuels, and hydrogen) at competitive prices in a free market. Many of the Fuels and Power Systems technologies, after achieving their performance goals, will be integrated into the Vision 21 concept. FY 2002 power systems activities tied to Vision 21 include achieving ultra-high efficiencies by working toward integrating advanced components such as a coal gasifier, fuel cell and turbine.

Significant progress towards achieving these goals will be made in FY 2002 in the Clean Coal Technology (CCT) Demonstration Program as projects involving gasification, advanced fluidized bed combustion, and fuel cell technology progress. Supporting CCT activities, an internet documentation database is now available that will allow stakeholders interested in the progress and implementation of CCTs to retrieve information. The infrastructure provided by the CCT projects is deployed, in certain cases, to advance the R&D program. Similarly, issues addressing systemic improvements in the technology from CCT projects are investigated under the R&D program.

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Fuels and Power Systems includes five elements: (1) Central Systems; (2) Distributed Generation Systems; (3) Sequestration R&D; (4) Fuels, and; (5) Advanced Research. Activities included in the \$61.0 million Central Systems request for FY 2002 are divided into two major areas. The first is Innovations for Existing Plants. A major thrust of this program area is the development of technology to comply with the requirements of the Clean Air Act Amendments (CAAA) of 1990 and new or pending regulations. The FY 2002 budget request emphasizes: development of retrofit NO_x control technologies for compliance with CAAA Title I and Title IV, Phase II regulations, and new PM_{2.5} and ozone National Ambient Air Quality Standards for essentially all existing coal-based power plants; determining PM_{2.5} source-receptor relationships as they relate to coal-fired power plant emissions; and field testing of air toxics control technologies. For mercury, no practical control technology now exists to significantly mitigate emissions from powerplants, so the focus is on both effectiveness and cost. In addition, there may be opportunities for innovative approaches which address two or more of these pollutants simultaneously.

The second area in Central Systems is Advanced Systems, which includes Low Emission Boiler System (LEBS), Indirect Fired Cycle (IFC), Pressurized Fluidized Bed (PFB) combustion, Integrated Gasification Combined Cycle (IGCC), and Advanced Turbines. The target for coal-fueled, advanced central systems is to achieve efficiencies in the 42-48 percent range in the 2000-2005 period that will provide the engineering foundation for system efficiencies in the 55-60 percent range. These latter improvements could reduce CO₂ emissions by over 40 percent compared to current coal-fired systems.

- C The LEBS program is drawing to a close. No further funding is requested in FY 2002.
- C IFC/PFB are being refocused to emphasize hybrid systems. IFC incorporates a new high temperature advanced furnace and pyrolyzer which integrates combustion, heat transfer and emission control processes. In FY 2002, the applicable combustion technology for Vision 21 is folded into the Vision 21 gasification/combustion hybrid concepts under IGCC. For PFB, major emphasis in FY 2002 will shift to provide the key scale-up technology for gasification/fluid bed combustion hybrids for Vision 21 concept options.
- C IGCC offers the potential for significant increases in thermal efficiency as well as significant reductions in capital costs, near-zero emissions of pollutants, and the ability to co-produce electricity and other valuable products. In FY 2002, the program will

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continue its focus on cost and efficiency improvements and performance optimization for power generation and co-production applications.

C The Advanced Gas Turbine Program work on utility-scale turbines will be completed in FY 2001.

The FY 2002 request for Distributed Generation Systems is \$45.1 million. These systems offer the potential to cost-effectively meet peak demand, and in some cases base and intermediate load, without the need for capital intensive central station capacity or costly investments in transmission and distribution. Fuel cell distributed generation systems have the additional advantage of being capable of reducing criteria pollutants well below current New Source Performance Standard levels, reducing non-criteria pollutants such as CO₂ and acid rain precursors, and reducing thermal emissions to the environment. In FY 2002, demonstration of a commercial-scale, 250kW molten carbonate fuel cell (MCFC) power plant system will be completed to verify its applicability for the combined heat and power, and distributed generation markets. A demonstration will also be completed of a 220 kW - 320 kW solid oxide fuel cell (SOFC)/turbine hybrid commercial prototype in support of Vision 21. Successful demonstrations could result in the construction of manufacturing facilities in the U.S. A growing thrust of the program is development of a low cost 5-kilowatt solid state fuel cell for distributed and auxiliary power unit applications. Toward this end, the Solid State Energy Conversion Alliance (SECA) provides a forum to bring entities together which are interested in low-cost, high power-density, solid state fuel cell systems for distributed generation and auxiliary power unit applications. SECA is committed to developing advanced technology that can be readily customized, while still being mass produced to reduce costs, with an initial cost target of \$400/kilowatt for a complete solid state system.

Sequestration R&D explores the potential for greenhouse gas reduction, particularly carbon dioxide. FE's sequestration research, which is part of a larger DOE Sequestration Initiative, is being carried out in collaboration with other parts of the Department, other government agencies, national laboratories, other countries, and industrial firms, and pursues a balanced set of approaches to establish both the environmental acceptability and the required technical and economic performance. The FY 2002 request of \$20.7 million for Sequestration R&D will carry to "proof-of-concept" completion a number of applied R&D options being investigated as part of prior solicitations. For example, integrated research and field demonstrations of CO₂ sequestration in deep, unminable coal seams and depleted oil reservoirs will be conducted and sufficient data developed to determine reservoir integrity and the fate of injected CO₂. The

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long-term program goal is to achieve large-scale carbon sequestration at \$10/ton, which could lead to the reduction of carbon emissions by 145 million tons per year in the U.S. and 270 million tons worldwide by 2030.

The FY 2002 request for Fuels R&D is \$7.0 million and focuses on development of critical components of the fuels technology program. This includes continued development of new ceramic membranes that would separate coal gas, biomass-derived gas, or natural gas into constituents that could be chemically combined to new types of liquid fuels. Also included is advanced technologies to create new industries for the production of premium carbon and industrial products from coal. No funding is requested for the steelmaking process, which is investigating the direct reduction of iron ore. Funding was completed in FY 2001.

The FY 2002 request for Advanced Research is \$26.0 million, which funds two types of activities. The first is a set of crosscutting studies and assessment activities in environmental, technical and economic analyses, coal technology export and international program support. The second includes crosscutting fundamental and applied research programs that focus upon developing the technology base in the enabling science and technology areas that are critical to the successful development of both superclean, very high efficiency coal-based power systems and coal-based fuel systems, with greatly reduced or no net emissions of CO₂. These systems are encompassed in the Vision 21 energyplex. Advanced Research seeks a greater understanding of the physical, chemical, biological and thermodynamic barriers to achieving economic, technologic, and environmental goals and to identify ways to overcome those barriers.

Significant potential benefits can be realized from achieving the Coal and Power Systems goals. For example, combining high efficiency power generation with carbon sequestration technology has the potential to reduce global carbon emissions by more than 500 million tons per year by 2030, and by much more as the existing portfolio of powerplants retires and is replaced by improved technology. Potential savings in cost of electricity is estimated at 0.5 billion per year by 2015, reaching \$2.5 billion per year in 2030, and contributing to power plant sales of \$10 billion per year in 2030.

Natural Gas Technologies

In FY 2002, \$21.0 million is requested for Natural Gas Technologies. This includes activities to help ensure that future domestic gas supplies are adequate and reasonably priced. EIA, in its 2001 Annual Energy Outlook (AEO2000), projects over a 60 percent increase

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in domestic natural gas consumption between 2000 and 2020, with nearly two-thirds used for electric power generation. This requires increasing gas production from parts of the vast domestic resource base that are not currently economical to recover because of the geological setting, quality of the gas, or location relative to infrastructure. The gas program focuses on technical and market needs, and is closely coordinated with industry. Activities seek to ensure long-term availability and reliability of natural gas at reasonable prices and to improve the Nation's ability to store, transport, and distribute gas in an economic, efficient, and environmentally beneficial manner. Major R&D elements include: Exploration and Production; Gas Hydrates; Infrastructure; and Effective Environmental Protection.

The Exploration and Production request for FY 2002 is \$9.4 million, and includes a range of activities, foremost of which are:

- C Advanced Drilling, Completion, and Stimulation projects to develop and demonstrate tools and techniques that will result in minimum formation damage, reduce costs and improve recovery, and minimize the environmental impact of drilling-related operations and waste disposal. FY 2002 cost reduction activities include development of the world's first microwave-processed drill bit and composite drill pipe.
- C Advanced Diagnostics and Imaging Systems to develop and demonstrate advanced imaging and prediction techniques for locating productive areas within low-permeability and fractured reservoirs, and identify and assess the potential productivity of non-conventional gas reservoirs in priority basins to reduce exploration and production risks. These technologies will reduce the number of dry holes; improve production from fractured reservoirs; increase U.S. exploration through greater industry access to and use of geologic and geophysical basin-scale data; and increase the cost effectiveness of field development, infill drilling, and extraction processes.

The \$4.8 million request for Gas Hydrates is a long-term effort seeking to convert the potential gas hydrates resource (estimated at up to 320,000 Tcf) into gas reserves while developing technologies to assure safe petroleum operations in hydrate areas, and define the impact of methane hydrates on the global carbon cycle.

Fossil Energy's \$5.1 million Infrastructure Technology program includes activities to enhance the reliability and deliverability of the Nation's natural gas pipelines and gas storage facilities. These efforts are motivated by increasing concern about the integrity and

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adequacy of the gas delivery and storage infrastructure. This is one of the critical barriers to achieving 30 TCF domestic consumption, projected by 2015, given the age of the existing pipelines, declining industry R&D for enhancing pipeline infrastructure, an uncertain regulatory climate, and long lead times required for new pipeline construction. FY 2002 activities include development of advanced storage technologies for high deliverability facilities and smart automated inside pipeline inspection systems and repair technology.

The Effective Environmental Protection program request is \$1.6 million. The program works to lower the cost of environmental protection through a combination of risk assessment technology development, regulatory streamlining, impact analysis, and facilitating dialogue that attempts to achieve consensus among affected parties on ways to balance the need to develop the Nation's energy resources with the maintenance of our environmental values.

Oil Technology

In FY 2002, \$30.5 million is requested for the Oil Technology program, which seeks to enhance energy security through increased domestic production, as well as helping the U.S. to be a responsible steward of its oil resources. The combined impact of FE R&D could contribute toward preserving the availability of these resources, extending reservoir life, and increasing domestic production.

Objectives of the oil technology program include: stem the decline in domestic oil production; improve the capability of the Nation's petroleum industry to increase the supply of secure, domestic oil; and reduce and resolve environmental issues associated with domestic oil production and processing. These activities are carried out under the areas of Exploration and Production, Reservoir Life Extension and Management, and Effective Environmental Protection.

The FY 2002 request for Exploration and Production is \$20.4 million, which includes work in several areas:

- C Advanced Drilling, Completion, and Stimulation work focuses on developing tools and techniques to drill, complete and stimulate oil wells to reduce costs, improve well productivity, and reduce environmental impacts (smaller surface "footprint" and reduced drilling wastes). FY 2002 activities include demonstrating safe, economic slimhole drilling technology under Arctic conditions.

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- C Advanced Diagnostics and Imaging Systems develops technologies and methodologies that improve the success rates and cost efficiencies for the development of existing fields and the discovery of new fields. A special focus is highly fractured reservoirs and ultra-deep geologic exploration and development environments.
- C Reservoir Efficiency Processes include research to develop and demonstrate tools and methodologies that permit oil operators to recover hydrocarbons from known reservoirs not producible by current technology.
- Arctic Oil and Gas Research will develop advanced technologies for production and use of energy in the Arctic environment.

The Reservoir Life Extension and Management program request is \$4.8 million to provide improved technology and/or more efficient methods to recover more of the 350 billion barrels of discovered but unproduced domestic oil resource, and increase recovery of oil from Federal lands. Evaluation of past advanced field trials in large, promising Class 1, 2, and 3 reservoirs will be completed. Demonstration and testing of technologies specifically targeted for independent operators will be continued.

The Effective Environmental Protection FY 2002 request is \$5.3 million for technologies and practices that reduce the threat to the environment and decrease the cost of effective environmental protection and compliance involved in oil exploration, production, and oil processing. The program will focus on detection and control of air emissions from gas and oil equipment and facilities, treatment and reduction of produced water to meet environmental standards, remediation of soils that have been contaminated with hydrocarbons or produced water, treatment and disposal of wastes containing naturally occurring radioactive materials, underground injection of produced water, and other approaches to manage oil and gas field wastes.

Research currently conducted under Ultra Clean Fuels to develop technology for the refining industry to make low sulfur fuel was determined to be most appropriately funded by the private sector. No funding is requested for this activity in FY 2002.

External Inputs to FE Program Planning

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A number of distinguished expert groups representing industry and academia have provided guidance on FE program priorities. For example:

- C The President's Committee of Advisors on Science and Technology (PCAST), in its November 1997 report "Federal Energy Research and Development for the Challenges of the Twenty-First Century," recommended strong support for: (1) Vision 21, zero-emission energy plants capable of producing combinations of energy, heat, fuels and chemicals from carbonaceous fuels; (2) new approaches for capturing and sequestering carbon; (3) developing a science-based program with industry, Federal Agencies and the Navy to understand the potential of methane hydrates worldwide; (4) technology transfer and cost-effective demonstrations to help maintain production from mature and marginal regions of domestic oil production; and (5) foundation building R&D in universities and National Laboratories to help maintain the energy technology leadership of the United States.
- C The June 1999 PCAST report "Powerful Partnerships – The Federal Role in International Cooperation on Energy Innovation" addresses ways to improve the U.S. program of international cooperation on Energy R&D to best support U.S. priorities and address the key global energy environmental challenges of the next century. The report includes funding recommendations for a variety of initiatives that include approaches such as tax credits, regulatory assistance, training and Federally-supported R&D.
- C Industry groups, particularly formal advisory groups such as the National Coal Council, National Petroleum Council, and the recently-formed Methane Hydrate Advisory Committee, provide periodic guidance. Of particular importance to oil and gas R&D activities is the December 1999 National Petroleum Council report on Natural Gas. Other important reports include survey results from the National Petroleum Council study "Research, Development, and Demonstration Needs of the Oil and Gas Industry," and the Petroleum Technology Transfer Council Needs Assessment. These surveys identified potential high benefit R&D areas, considering the near- and long-term needs of both the supply and utilization sectors, where industry respondents, for a variety of reasons, do not believe the oil and gas industries will make adequate progress on their own.
- C Public input is obtained through workshops on various topics held throughout the year.

Other Program and Crosscutting Areas

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FE is taking steps to ensure that the U.S. benefits directly from cooperative research with foreign governments and multilateral institutions as well as enhanced international regulatory coordination. FE is also working with other Departmental groups, Federal agencies, international organizations and private sector companies to promote the export of domestic fossil fuel technology, including highly efficient processes that can reduce global greenhouse gas emissions.

In the area of Environmental Restoration, FE is working to provide a safe environment at the FE R&D facilities, as well as at off-site locations where R&D projects are sponsored. In addition, FE is responsible for correcting environment, safety and health (ES&H) problems at the Albany Center, a former U.S. Bureau of Mines facility that was transferred to FE in 1997. FY 2002 funding at a level of \$9.5 million is targeted at corrective actions to ensure that the FE R&D facilities are operating in compliance with Federal, state and local ES&H requirements, and that the environmental contamination associated with the on-site operations and off-site locations is remediated. The major share of funding will focus on environmental remediation, indoor air quality and ventilation, industrial safety, emergency preparedness, fire protection, control of toxic and hazardous materials, and protection of water and air quality. A sustained commitment to ES&H is an important factor in retaining public trust in the conduct of FE activities.

The FY 2002 request for Program Direction and Management Support is \$70.0 million. This provides funding for salaries, benefits and overhead expenses for management of the Fossil Energy program at Headquarters and the National Energy Technology Laboratory (NETL), with sites in Morgantown, WV, Pittsburgh, PA and Tulsa, OK.

The FY 2002 request for the Import/Export Authorization Program is \$1.0 million, which promotes the development of interfuel competition and markets for U.S. natural gas and electricity through regulation of natural gas imports and exports, exports of electricity, and the construction and operation of electric transmission lines which cross U.S. international borders.

The Advanced Metallurgical Processes Program at Albany, Oregon, for which \$5.2 million is requested in FY 2002, seeks to determine the factors that limit service life of materials in industrial, structural, or engineering applications and provide solutions to service-life problems through new materials technology, to develop and demonstrate technologies that will reduce waste and pollution, and to use capabilities and expertise to provide focused solutions to high priority national problems. The research at Albany provides information on the performance characteristics of materials being specified for the current generation of fossil-fueled power systems, on the

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development of cost-effective materials for inclusion in Vision 21 systems, and for solving environmental emission problems related to fossil fired energy systems. This program stresses full participation with industry and emphasizes cost sharing to the extent possible.